

CLAIMS:

1. A method for extracting water from an aqueous solution of a protein comprising the steps of:

(a) intermixing the aqueous solution of the protein with a sufficient quantity of at least one glycol ether at a temperature at least 30 centigrade degrees above the lower critical solution temperature (LCST) to form a suspension comprising a concentrated aqueous protein phase and a liquid organic phase comprising said at least one glycol ether and at least 10 percent water extracted from the aqueous solution of the protein, wherein the glycol ether has an inverse solubility in water, with the proviso that the solubility of the glycol ether in water is significantly less than the solubility of water in the glycol ether, and the glycol ether does not significantly deactivate the protein, and

(b) separating the concentrated aqueous protein phase formed in step (a) from at least a portion of the liquid organic phase.

2. The method of Claim 1 wherein the glycol ether has the formula



wherein R' is an alkyl group of 1 to 8 carbon atoms; R'' is, independently in each occurrence, hydrogen, methyl or ethyl; R''' is hydrogen, an alkyl group having from 1 to 4 carbon atoms, a propionyl or an acetyl group; and n is an integer between 1 and 4; and wherein the glycol ether has an inverse solubility in water, with the proviso that the solubility of the glycol ether in water is significantly less than the solubility of water in the glycol ether, is capable of transporting at least 10 percent water into the organic layer, and does not deactivate or degrade the protein.

3. The method of Claim 1 or Claim 2, wherein the intermixing of the glycol ether with the aqueous solution of the protein in step (a) is conducted at a temperature of from about -5°C to about 70°C.

4. The method of Claim 1 or Claim 2, wherein, in step (b), a portion of the liquid organic phase is allowed to remain with the concentrated aqueous protein phase in an amount from about 1 to about 30 percent by weight.

5. The method of Claim 1 or 2, wherein, in step (b), substantially all of the liquid organic phase is separated from the concentrated aqueous protein phase.

6. The method of Claim 1 or Claim 2, further comprising the steps of:

(c) heating the liquid organic phase obtained in step (b) to a temperature which is higher than the temperature in step (a) to form a suspension comprising an aqueous phase and a glycol ether phase, and

5 (d) separating the glycol ether phase formed in step (c) from the aqueous phase.

7. The method of Claim 6, wherein in step (c) the liquid organic phase is heated at a temperature of from about 40°C to about 100°C.

8. The method of Claim 1 or Claim 2, wherein the concentrated aqueous protein
10 phase obtained in step (b) is further contacted with a hydrophobic organic solvent.

9. The method of Claim 4, wherein the aqueous phase obtained in step (d) is further contacted with a hydrophobic organic solvent.

10. The method of Claim 1 or Claim 2, wherein the protein is an enzyme or a therapeutic protein.

15 11. The method of Claim 2, wherein the glycol ether is selected from the group consisting of tripropylene glycol ethyl ether, propylene glycol isopropyl ether, dipropylene glycol isopropyl ether, tripropylene glycol isopropyl ether, propylene glycol n-propyl ether, dipropylene glycol n-propyl ether, propylene glycol t-butyl ether, dipropylene glycol t-butyl ether, tripropylene glycol t-butyl ether, propylene glycol
20 n-butyl ether, dipropylene glycol n-butyl ether, tripropylene glycol n-butyl ether, propylene glycol n-pentyl ether, propylene glycol n-hexyl ether, butylene glycol methyl ether, dibutylene glycol methyl ether, butylene glycol ethyl ether and dibutylene glycol ethyl ether, ethylene glycol n-butyl ether, ethylene glycol n-pentyl ether, ethylene glycol n-hexyl ether, ethylene glycol n-heptyl ether, ethylene glycol 2-ethylhexyl ether,
25 diethylene glycol n-pentyl ether, diethylene glycol n-hexyl ether, diethylene glycol n-heptyl ether, triethylene glycol n-hexyl ether, ethylene glycol n-butyl ether acetate, propylene glycol isobutyl ether, dipropylene glycol isobutyl ether, tripropylene glycol isobutyl ether, ethylene glycol t-butyl ether, ethylene glycol isobutyl ether, ethylene glycol isobutyl ether acetate, and diethylene glycol n-butyl ether acetate, and blends
30 thereof.